

Off-line calibration and monitoring

Olga Kodolova

Calibration & Monitoring Scenario (HB/HE)

(same to HF)

1) Before megatile insertion

- megatile scanner: **all tiles**
- moving wire source: **all tiles**

2.1) After megatile insertion

- moving wire source: **all tiles / 2 layer**
- UV laser: **2 layers/wedge**

2.2) After megatile insertion

- test beam: **a few wedges.**
- correspondance source–testbeam**

3) Before closing the CMS

- moving wire source: **all tiles**
- UV laser & blue LED: **all RBX**
- (do 3, about once/year)

4) Beam off times

- moving wire source: **2layer/wedge**
- UV laser: **2 layer/wedge**
- UV laser & blue LED: **all RBX**

5) Beam on

- in-situ **ECAL+HCAL**

Testbeam →

Absolute calib.
Accuracy of 2%
for single particle

Monitor for change
with time
Accuracy < 1%

once a few times/day (?)

HB a few
wedges

HE using
cosmic rays+
testbeam of
1 segment

HB–HE
transition
area to
testbeam

HF each
sector to
testbeam +
2 sectors
together

List of tasks

Calibration

In collaboration

- Calorimeter level energy scale
 - > Initial calibration with test-beam, source, etc *(with DSC team)*
 - > Hermecity (HE–HF boundary, HF wedges)
 - > in-situ (isolated particles, gamma/Z+jet, mass(jj))
 - > jets/MET energy scale *(with physics objects team)*

Monitoring

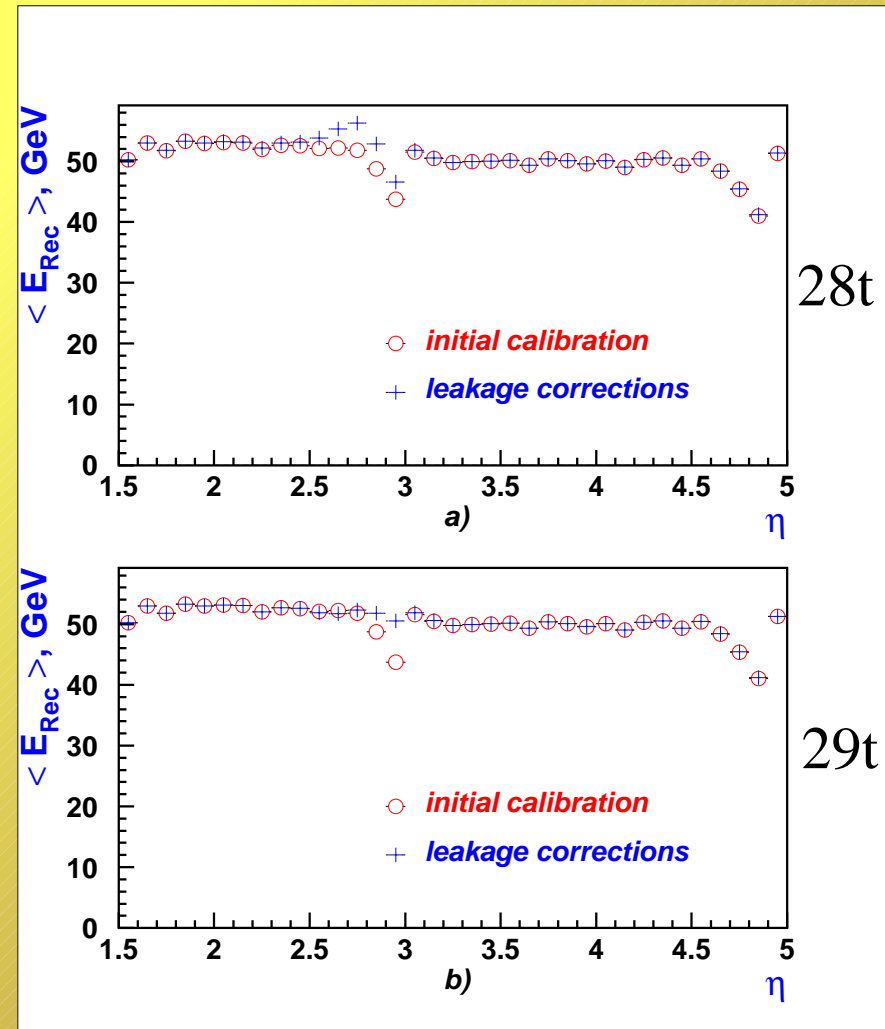
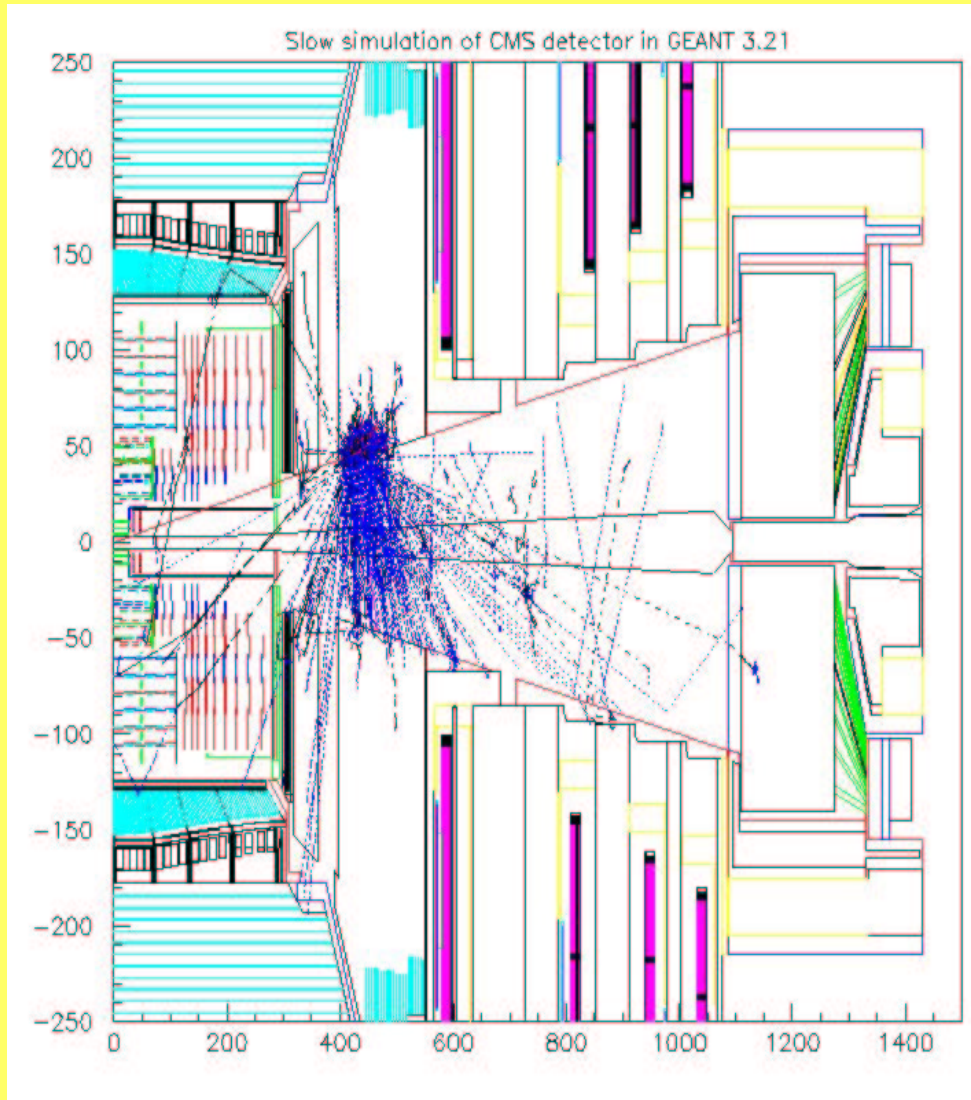
- > synchronization *(with DCS team)*
- > dead/hot channels
- > radiation damage

Software tools and data maintenance

- > bookkeeping *(with DCS team)*
- > ORCA–DB interface *(with HCAL software and simulation)*

Hermeticity: HE–HF

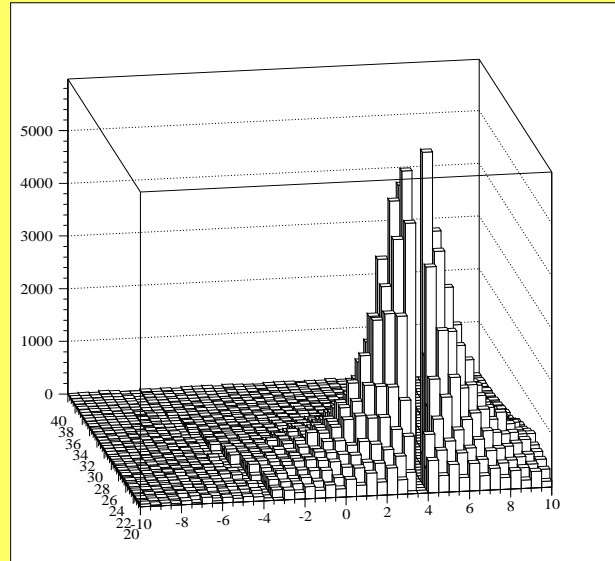
A.Krokhotine



Hermeticity: boundaries between HF wedges

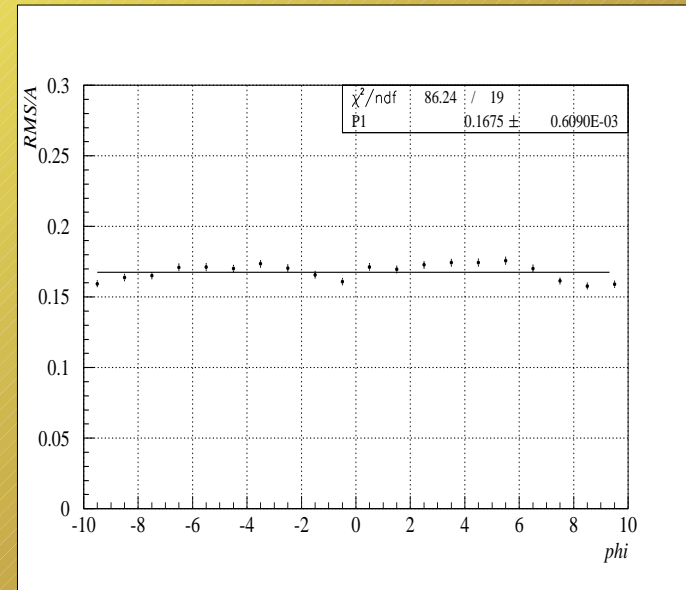
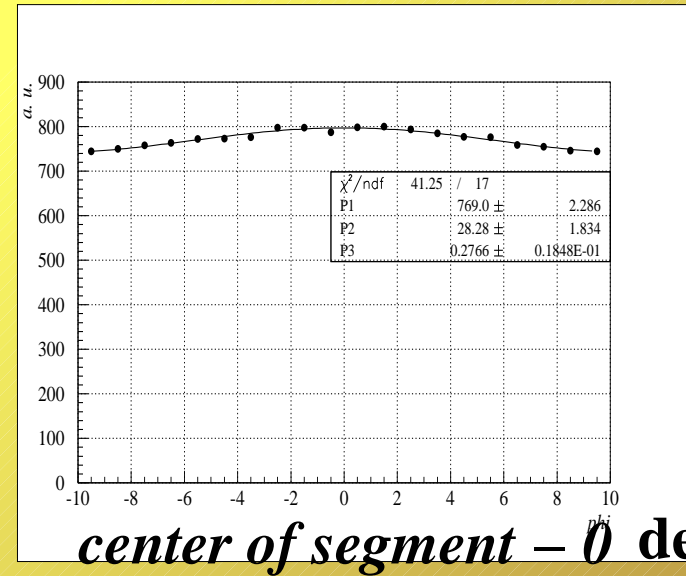
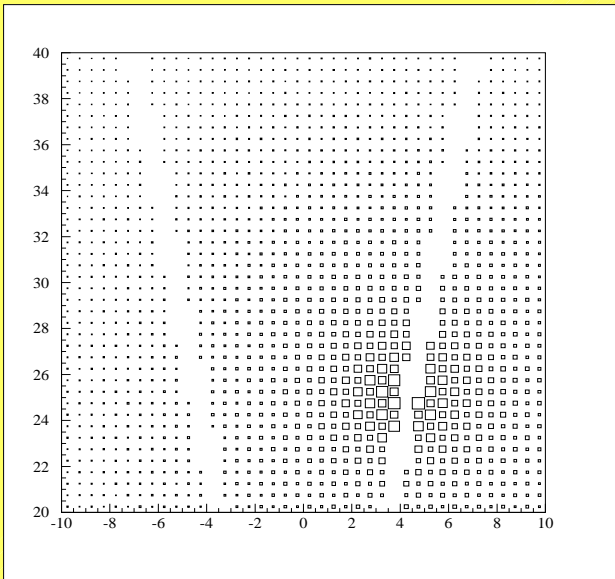
V.Kolosov

Nphe



1000 jets

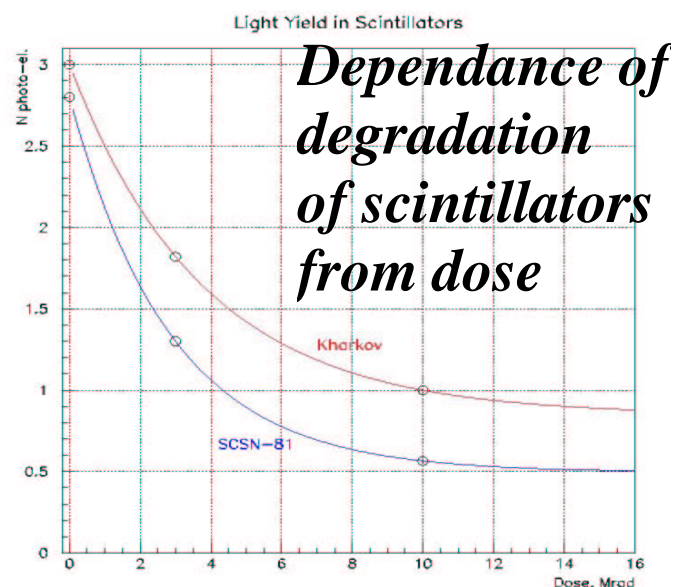
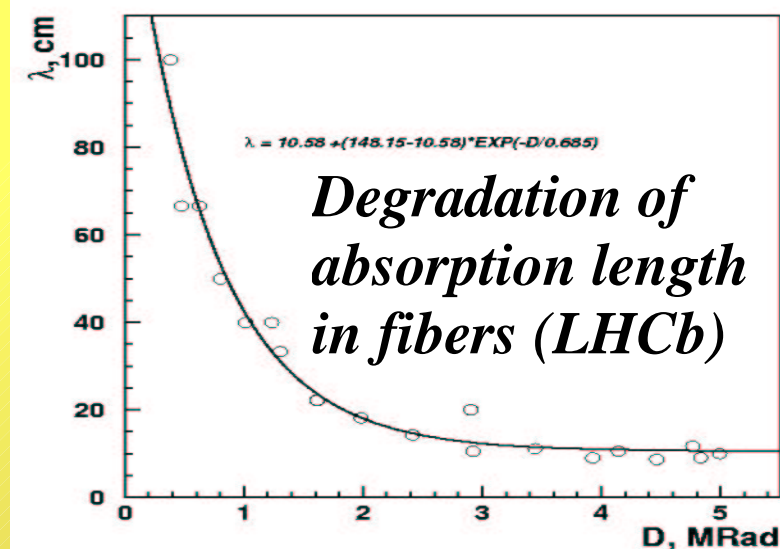
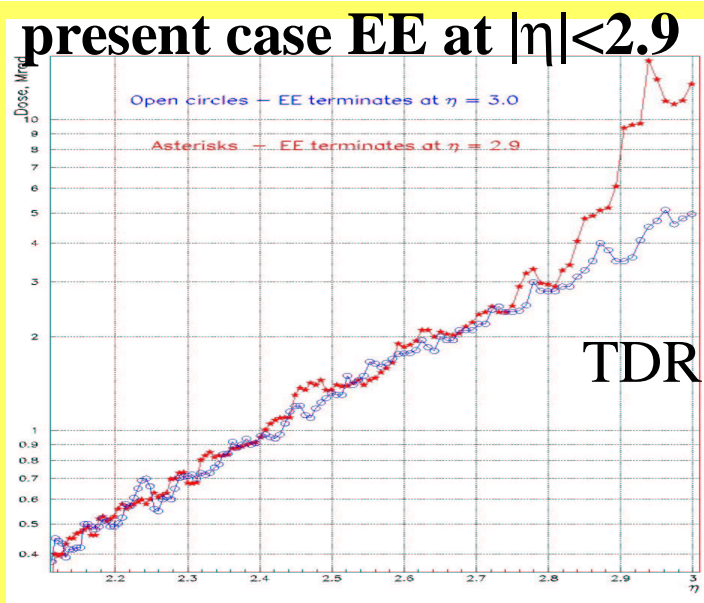
1 TeV jet
 $\eta=4.5$



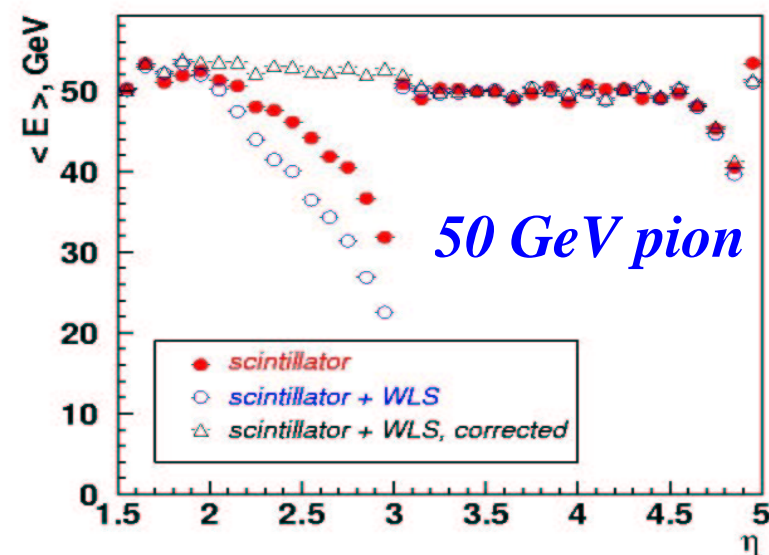
Radiation damage of HE (slide #1)

A.Krokhotine

*10 Mrad →
Radiation
doses in
endcap
for 10 years*



*How many
min bias for
correction?*

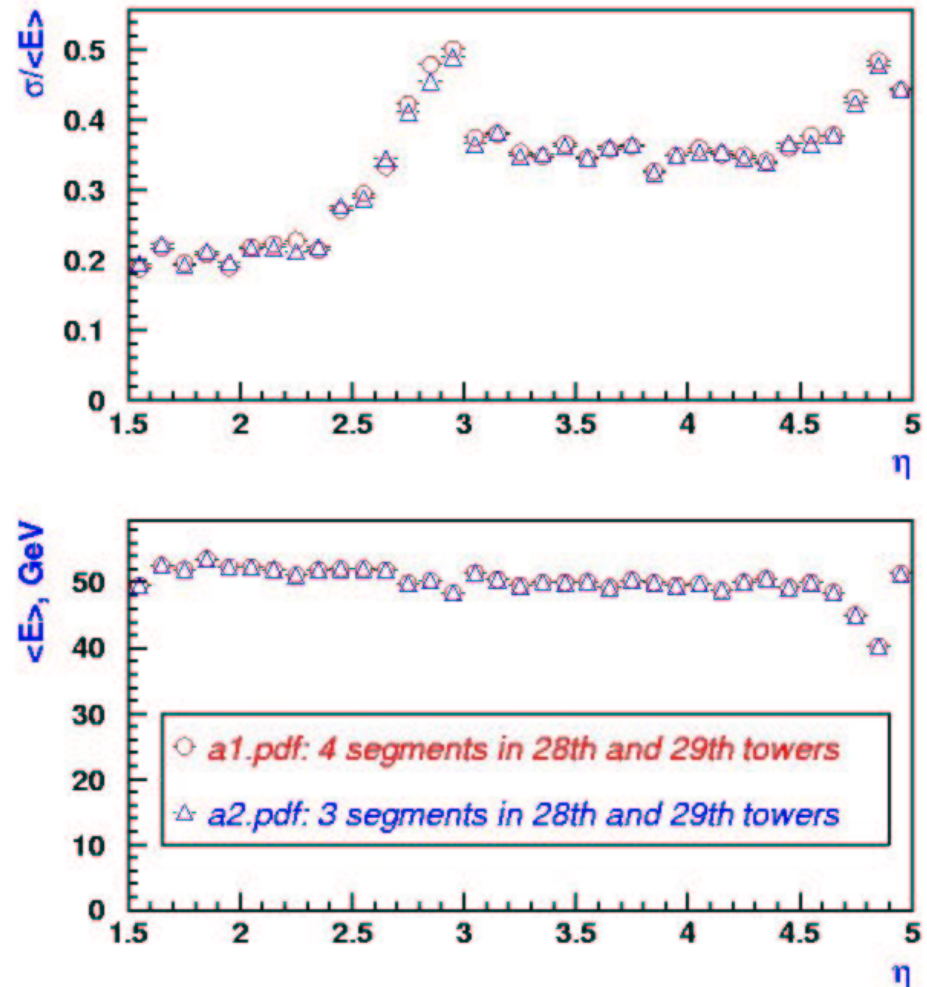
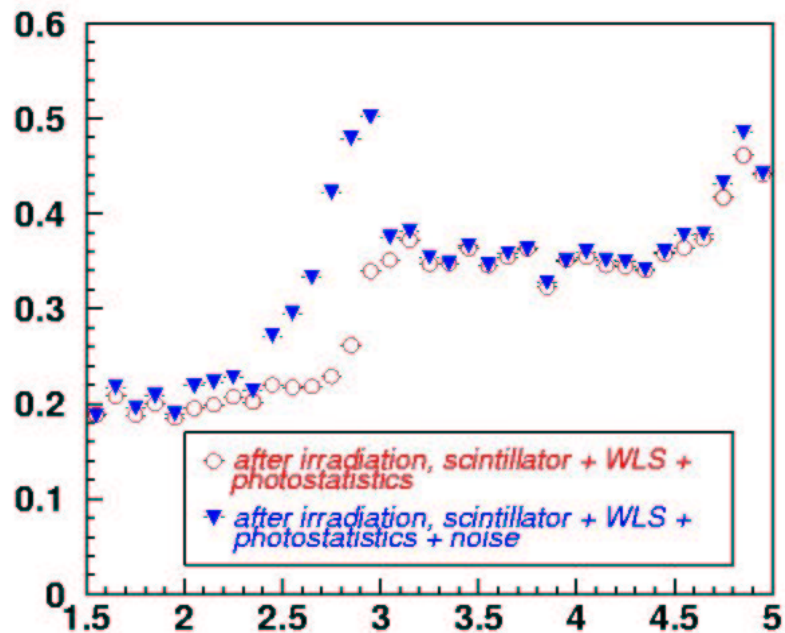


New

Radiation damage of HE (slide #2)

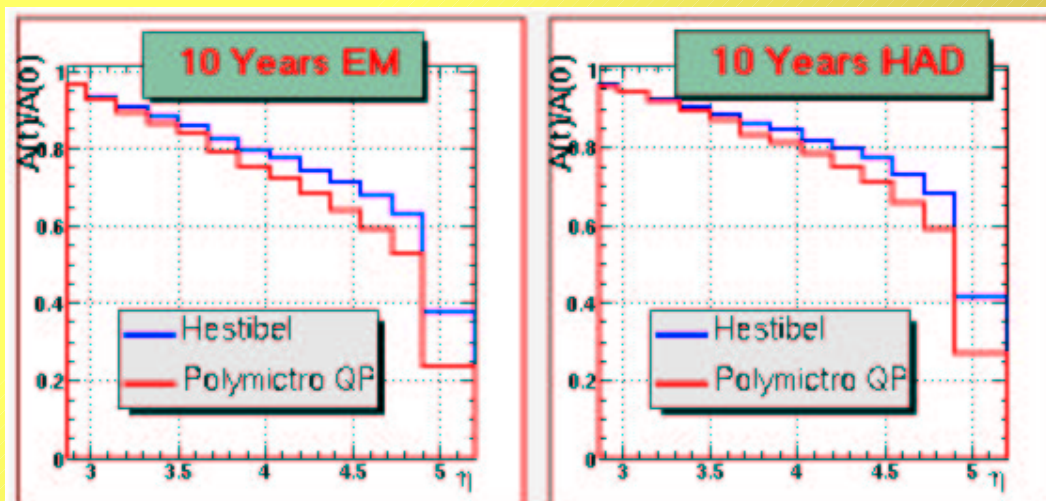
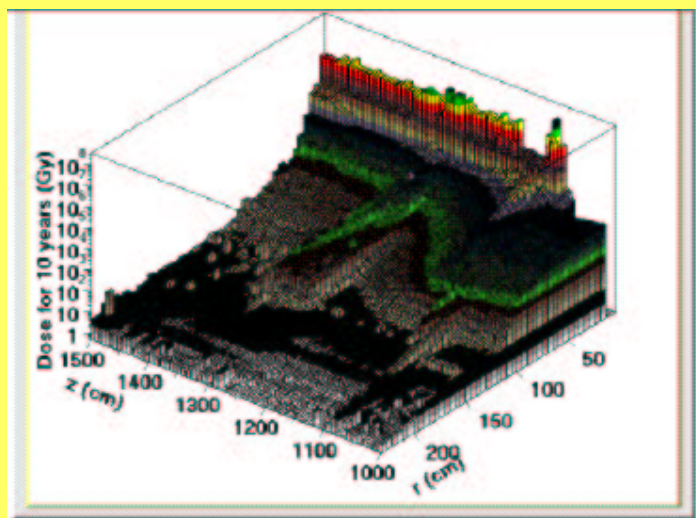
After corrections

Before corrections



Radiation damage in HF (slide #1)

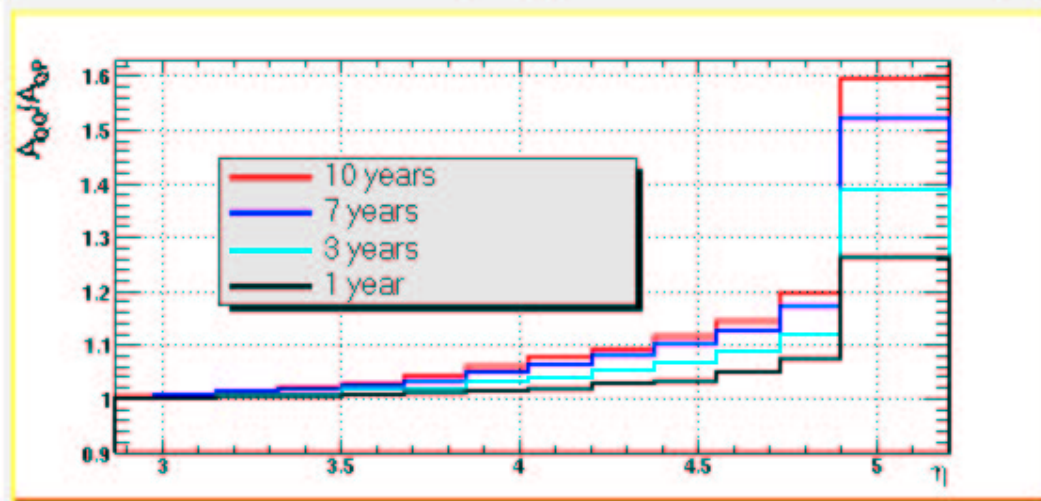
A.Gribushin



- >2K of Minimum Bias events ~400K p.e.
- CMSIM 125
- HF response with the shower library

Signal was then attenuated with parameters for **Hestibel quartz-quartz** and **Polymicro quartz-plastic fibers**

For the central towers ~60 to ~75% of the signal is lost after 10 years of operation



Possible corrections with min bias statistics?

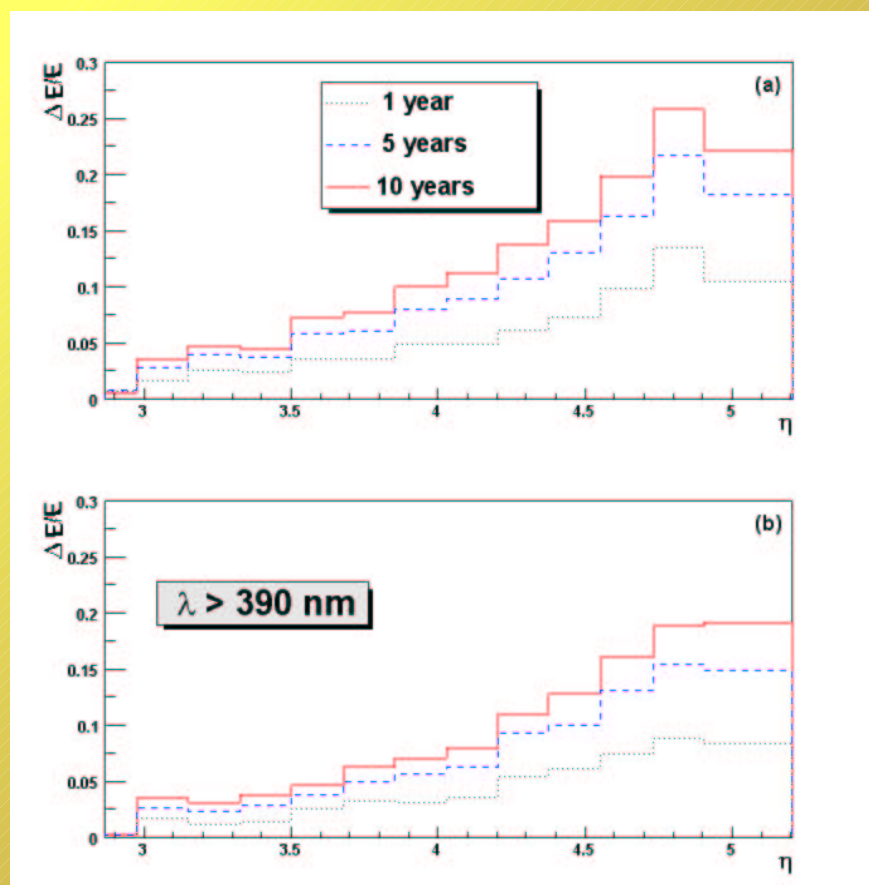
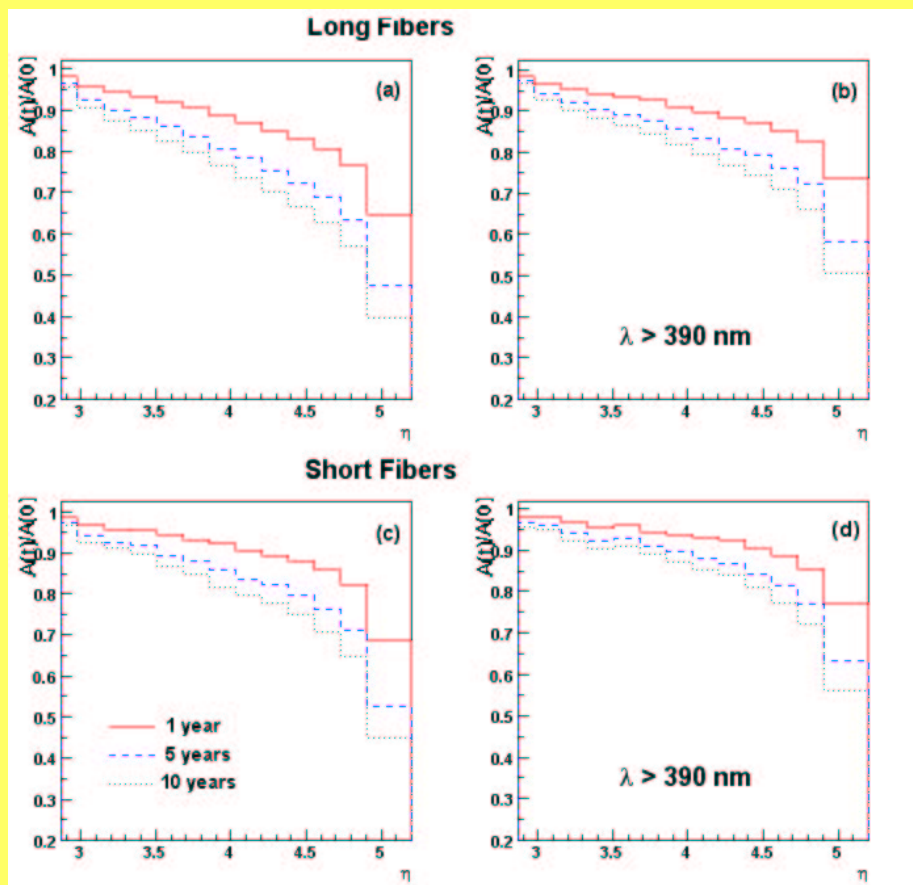
New

Radiation damage in HF (slide #2)

Polimicro quartz–plastic fibers

A.Gribushin

*Radiation damage parametrization
is a weighted average both Snezhinsk and CERN data*

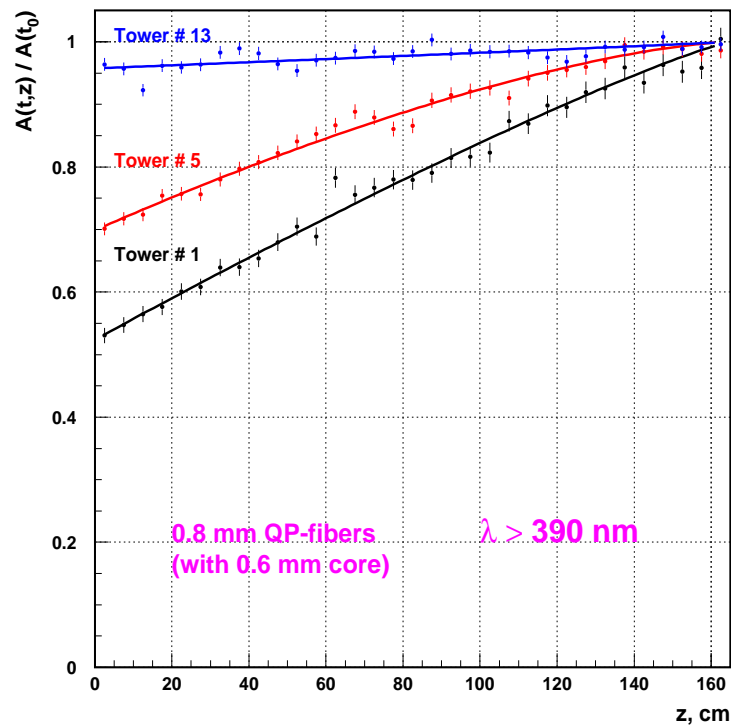


Dose map in the gap between absorber and PMT is also taken into account

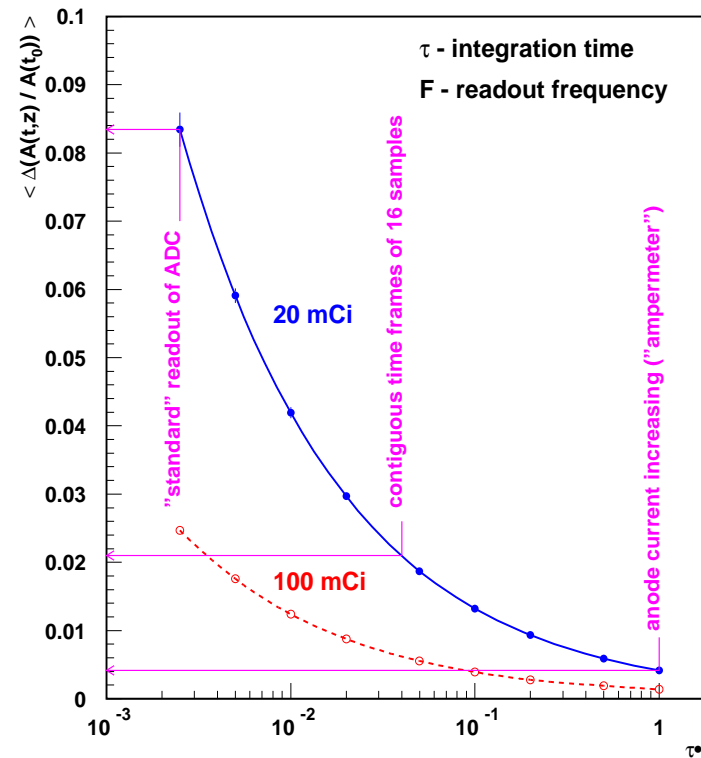
Radiation damage in HF (slide #3)

A. Erchov

Source signal reduction after 10 years of irradiation



Precision of the fiber transparency measurement



*Source is moving with speed
10 cm/sec. During each single
measurement it passes 5 cm.
i.e. 0.5 sec with 0.04% of integration time.*

*% of full integration time for
each point*

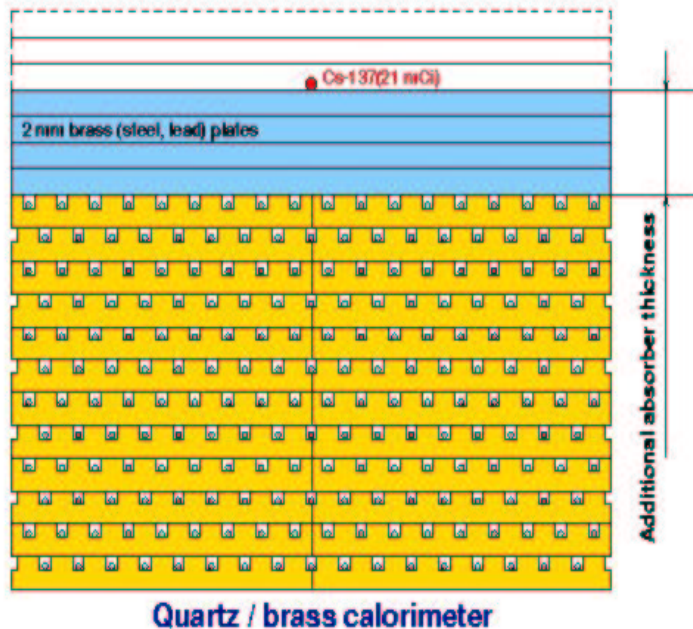
New

Radiation damage in HF (slide #3)

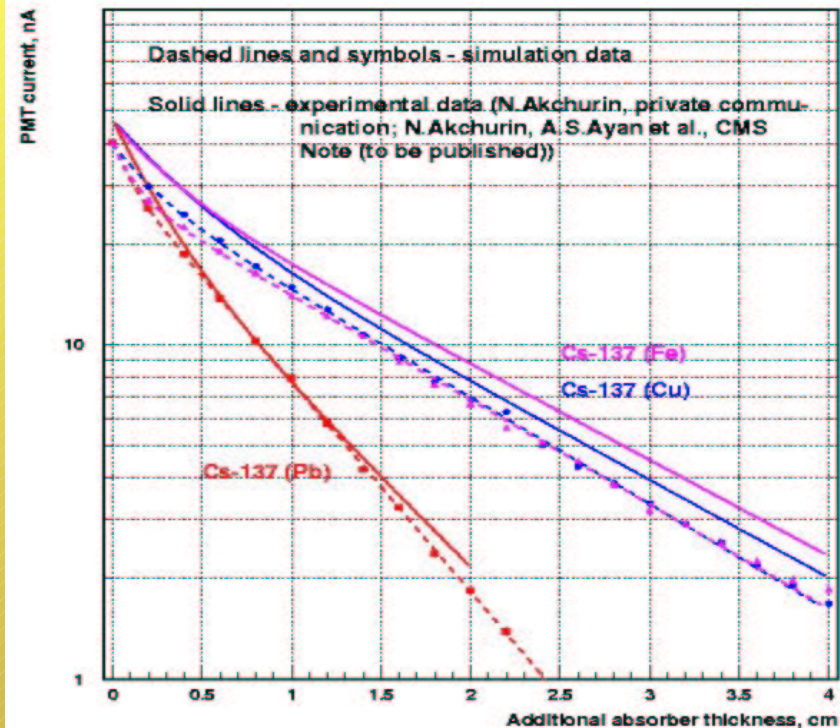
A.Erchov

Test of the simulation code for CMS HF calorimeter calibration with source
using test beam data provided by N.Akchurin (private communication)

Simulated experimental setup.



Measured and simulated signals in the quartz/brass calorimeter



In Situ Calibration

(Physics Event Trigger)

A) Min-bias events trigger

- estimation of pile-up energy.
- normalization within each eta-ring.
- isolated low E_T charged tracks ($|\eta| < 2.4$)

2% accuracy
with 1k events
in HF

B) QCD Jet trigger (pre-scaled)

- normalization within each eta-ring
- normalization at the HB-HE-HF boundary
- test on uniformity over full η range.
- dijet balancing to normalize E_T scale in η rings.
($|\eta| < 5$)

C) tau trigger

- isolated high E_t charged tracks ($E_t > 30 \text{ GeV}$) ($|\eta| < 2.4$)

D) muon trigger (isolated)

- good for monitoring. ($|\eta| < 2.4$)
- probably too small energy deposit for calibration.

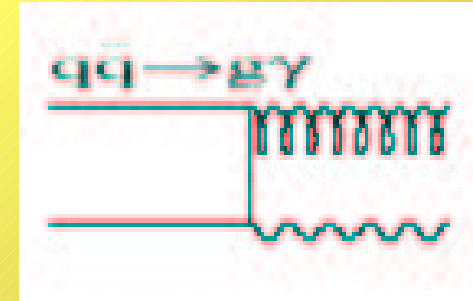
In Situ Calibration (2)

E) 1 photon + 1 jet

(Victor Konopliniakov)

- E_T Scale over full η range
by photon–jet balancing

($|\eta| < 5$)

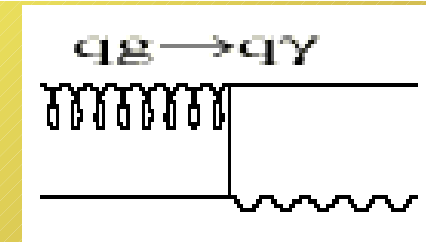


F) Z ($\rightarrow ee, \mu\mu$) + 1 jet

(Anarbay Urkinbaev)

- E_T Scale over full η range
by Z–jet balancing

($|\eta| < 5$)



G) Top trigger (1 lepton + jets + 2 b–tags) (Suman Bala(?))

- E_T scale by Mass(jj) for W in Top decay.

($|\eta| < 5$)

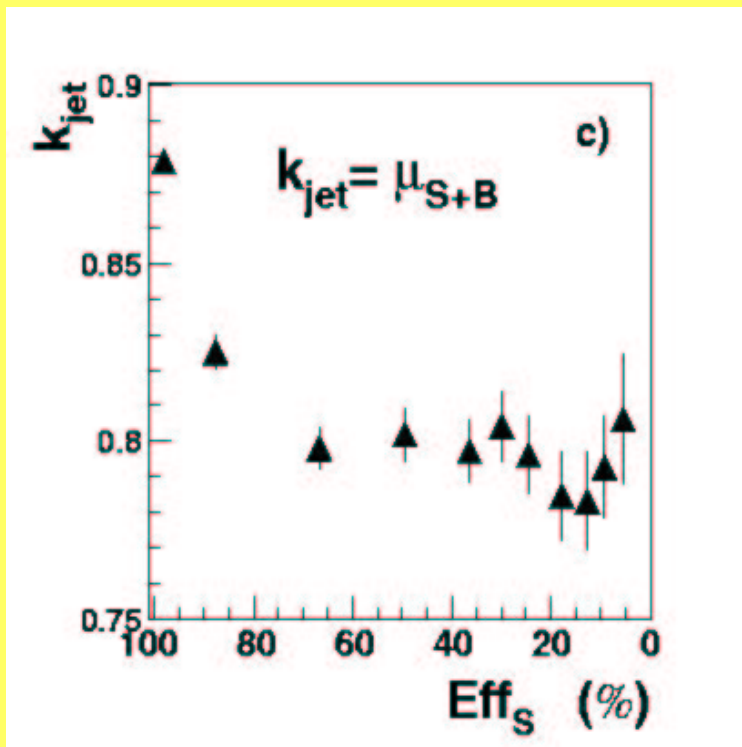
Need good understanding of trigger requirements and data streaming

New

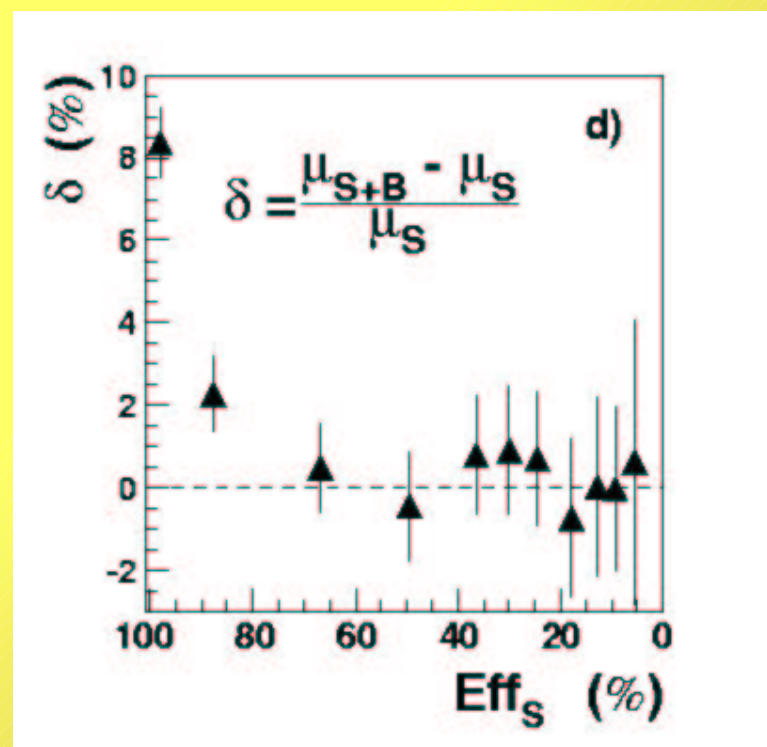
γ +jet calibration (slide #1): background influence

$$E_T^\gamma = 40 - 55 \text{ GeV}$$

V.Konopliannikov



Efficiency of signal



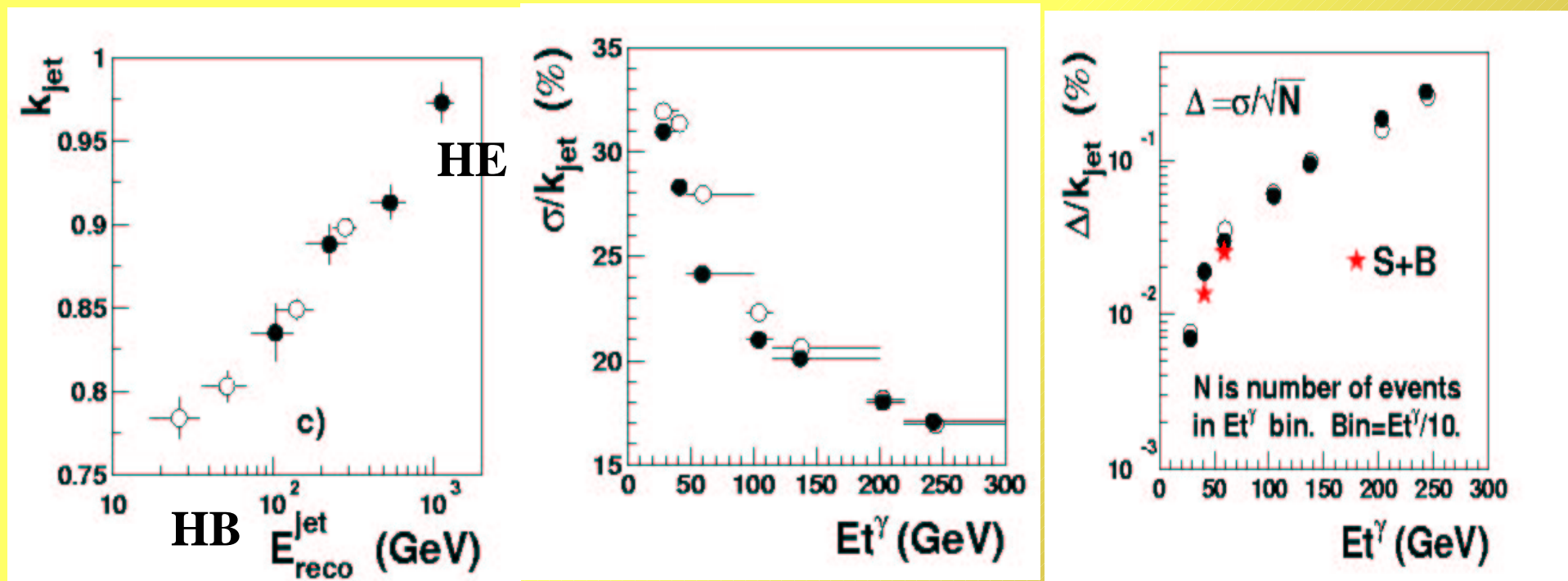
Systematical deviation due to background inclusion

Kjet is the position of peak of the distribution $E_{T\text{reco}}^{\text{jet}} / E_{T\text{reco}}^\gamma$

Background events do not disturb events beginning from 50% signal suppression level.

Cuts (eff=50%):
ETjet2 < 22 GeV
ETout1 < 32 GeV
 $\Delta\phi > 2.7$
 $ET_{\text{isol}}^\gamma < 3.9 \text{ GeV}$

γ +jet calibration (slide #2): errors



For 3 months – $2.5 \cdot 10^6$ sec (5 fb^{-1})

$E_T^\gamma = 20 - 300 \text{ GeV}$

Signal efficiency (%)	Number of event	S/B	error ($\sigma/(k \cdot \sqrt{N})$) %
50.00%	$10^8 - 10^4$	1	0.008 – 0.3
10.00%	$2 \cdot 10^7 - 10^3$	2	0.015 – 0.5

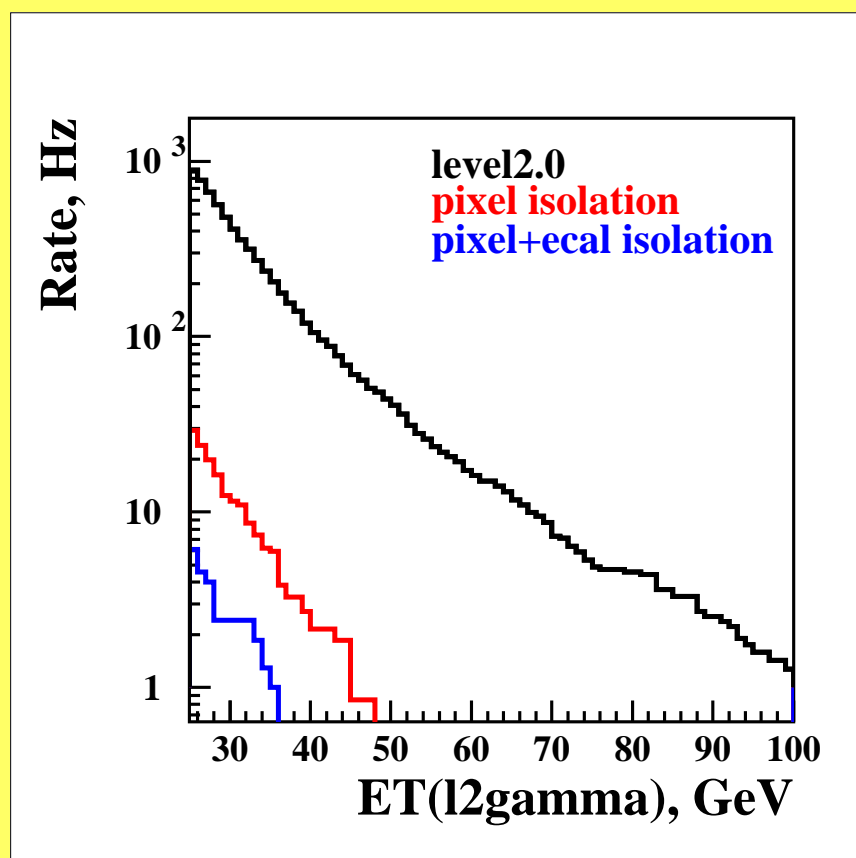
No pixel isolation

Time will increase considering trigger condition

γ +jet calibration (slide #3): trigger rates

A.Oulianov

Pixel and ECAL isolation



Only background sample

L2 gamma in $|\eta| < 1.5$

*No pixel lines ($PT > 1$ GeV/c)
inside cone $R=1$ around L2 gamma*

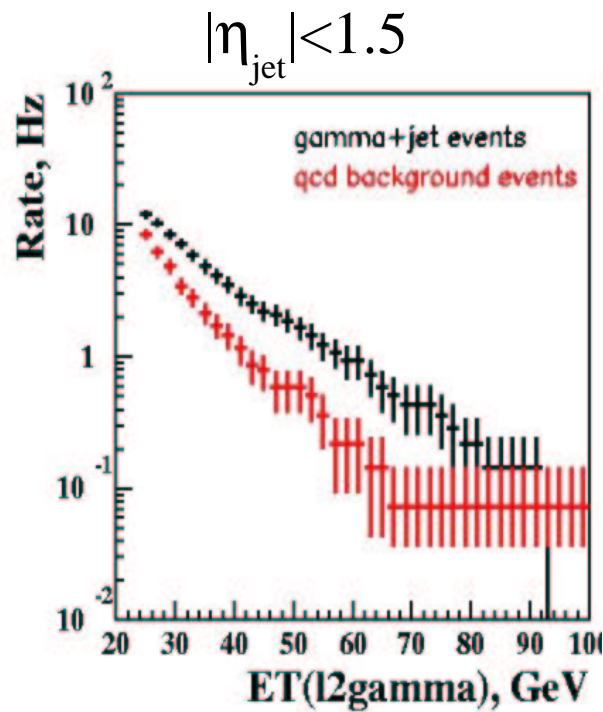
*Sum of ECAL digis ET (above
100MeV) in the range $0.07 < R < 0.5$
required to be less than 1.2 GeV*

*With signal rate will be ~4 Hz.
Probably prescaling will be usefull*

New

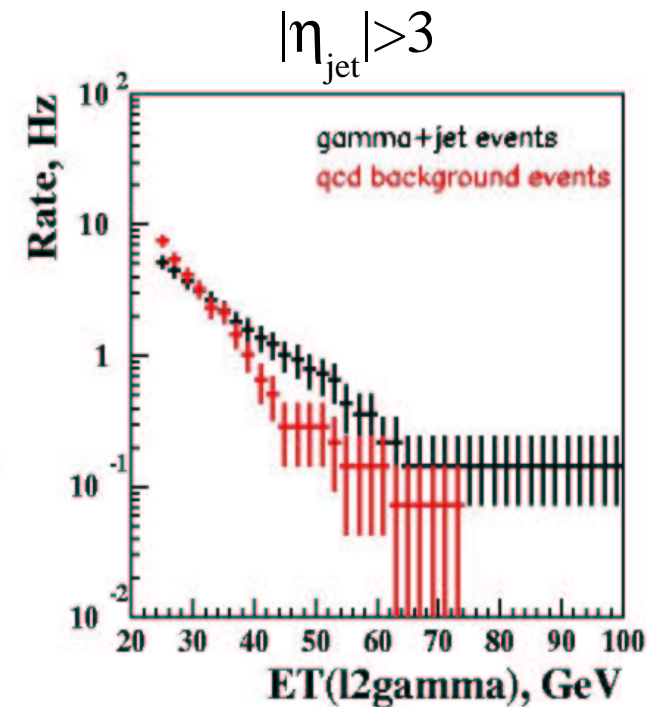
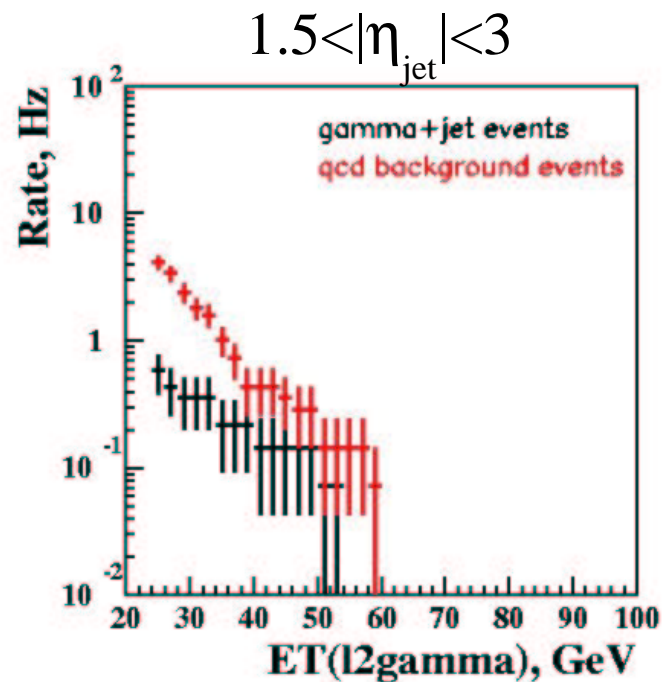
γ +jet calibration (slide #4): trigger rates

A.Oulianov



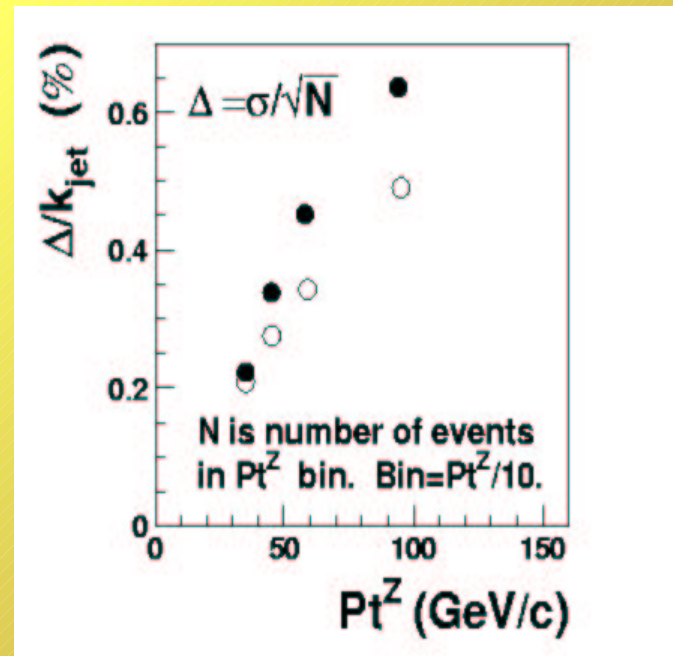
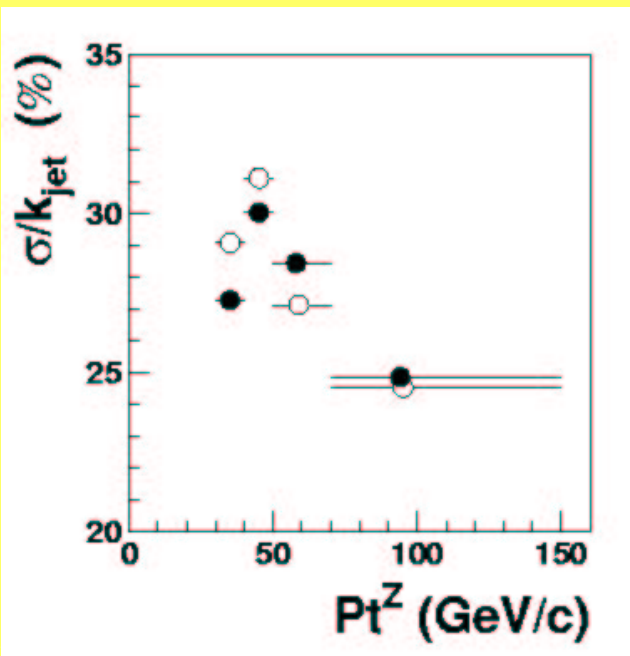
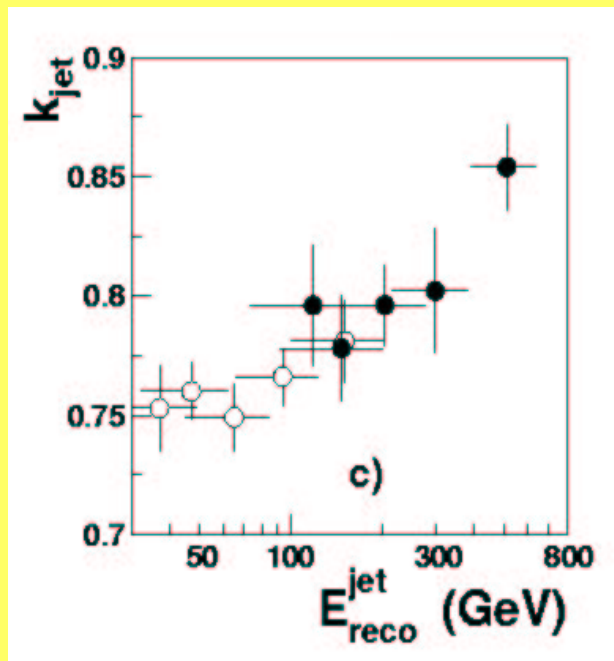
$|\eta_{\gamma}| < 1.5$

*Isolation of γ in
ECAL and pixels*



Z+jet calibration: errors

A.Urkinbaev



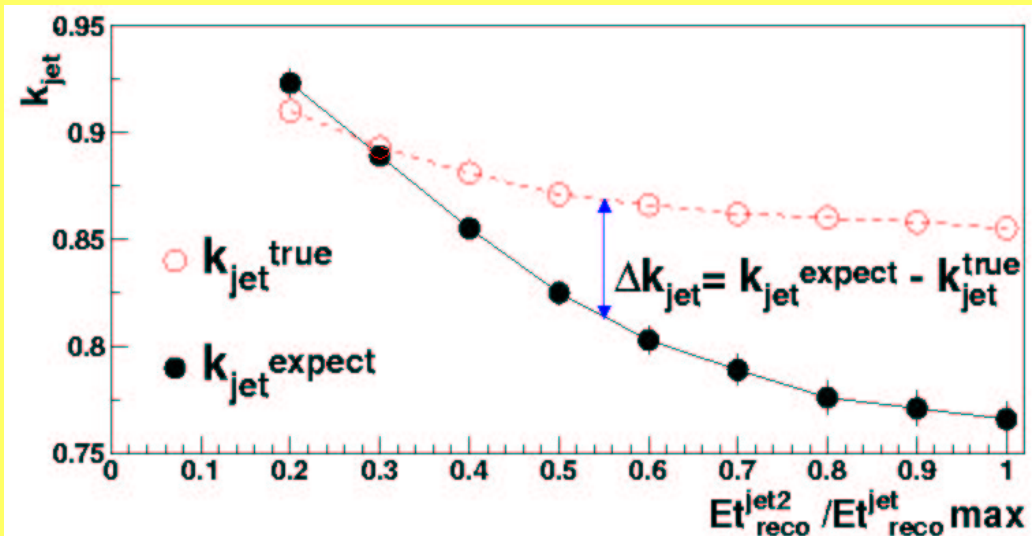
For 3 months – $2.5 \cdot 10^6$ sec

$E_T^Z = 20 - 100$ GeV

Signal efficiency (%)	Number of event	error ($\sigma/(k \cdot \sqrt{N})$) %
70.00%	$10^5 - 10^4$	0.2–0.5

No problems with trigger rate

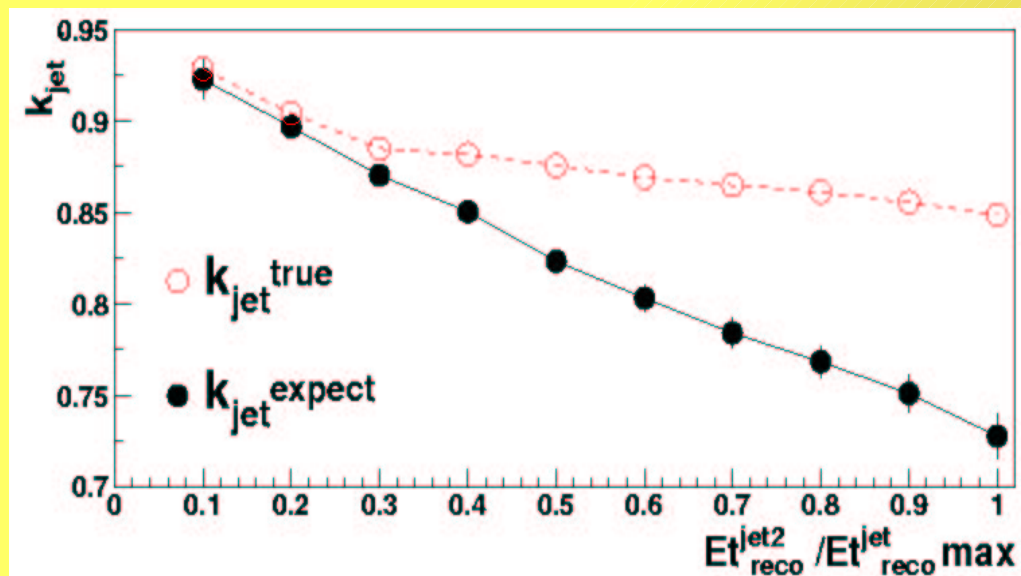
γ/Z +jet: conditions for calibration



$K_{\text{exp}} \rightarrow \text{peak of } E_{\text{Tjet}}^{\text{reco}} / E_{\text{T}}^{\gamma/Z}$

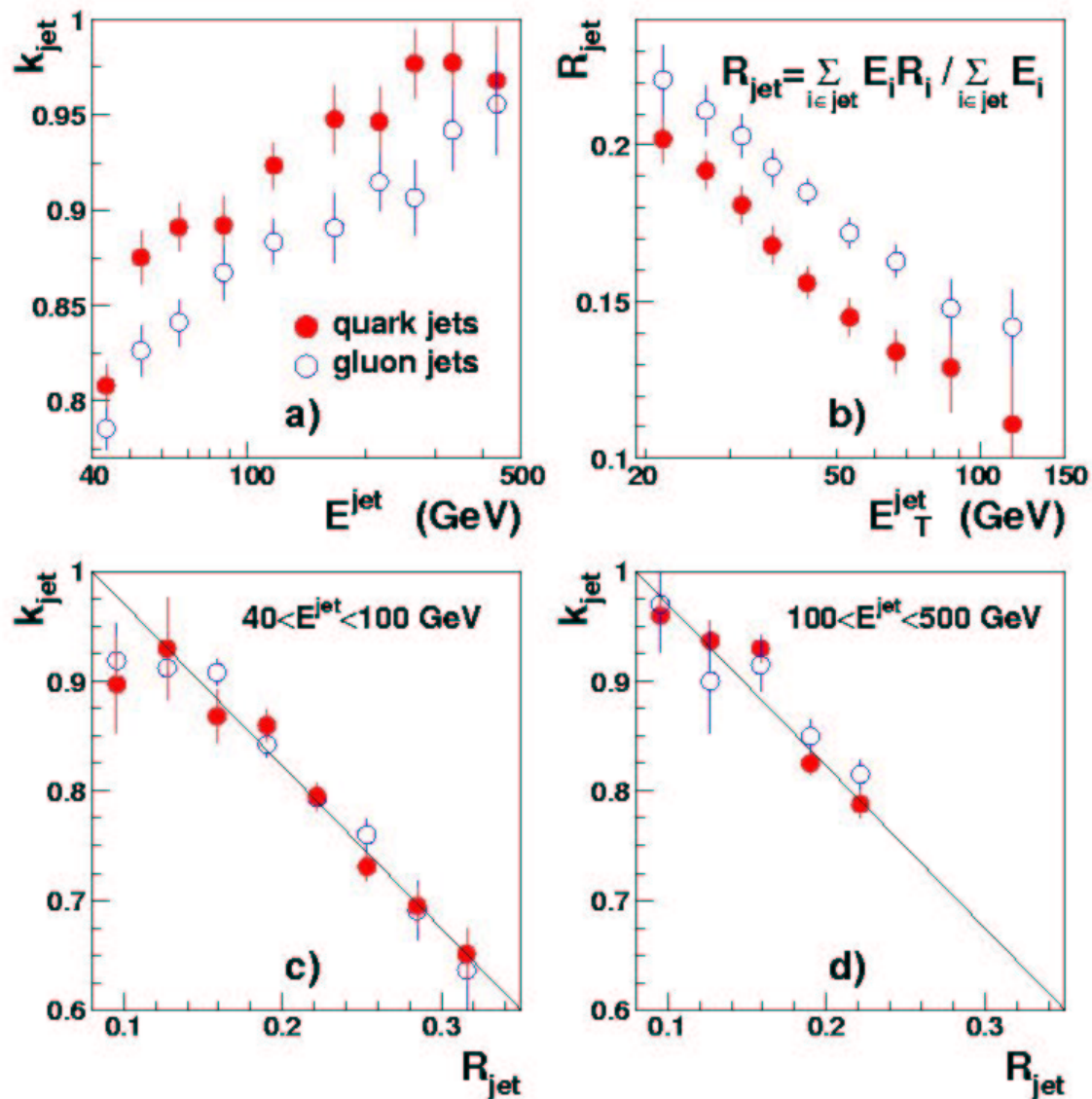
$K_{\text{true}} \rightarrow \text{peak of } E_{\text{Tjet}}^{\text{reco}} / E_{\text{T}}^{\text{particles}}$

$E_{\text{T}}^{\text{particles}}$ can be estimate from other methods (with tracker f.e.)



New

γ +jet: calibration for quark and gluon jets



Preliminary for $eff=50\%$

K_{jet}/R_{jet} does not depend on jet initiator (q or g)

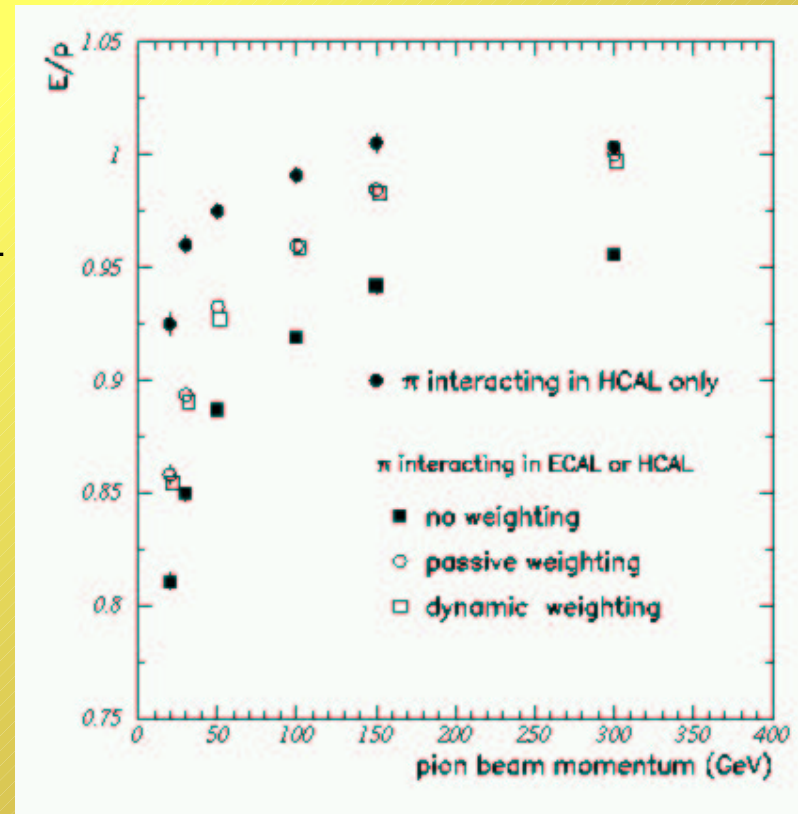
HLT Jets/MET and Energy Corrections (#1)

From jet physics (from parton to jet on particle level):

Fragmentation, ISR+FSR, underlying event, pile-up

From detector performance:

Magnetic field, noise, cracks, leakage, different response for e/gamma and hadrons etc



*E/ π for HCAL (1996 beam test)
non-linearity up to 15 %*

HLT Jets and Energy Corrections (#2)

Two steps for HLT jets

- *Find jets with $R=0.5 - 1.0$ with fixed calorimeter weights.*
- *Correct energy scale to sharpen turn on curve.*

Energy Correction

- *Jet based*
 - 1) $E = a \times (EC + HC)$, *a depends on jet(ET, η)*
 - 2) $E = a \times EC + b \times HC$, *a, b depend on jet(ET, η)*
- *Particle based*
 - 3) $E = em + had$ *(requires to separate em/had clusters)*
 $em = a \times EC$ *for e/γ*
 $had = b \times EC + c \times HC$, *for had. b (c) depend on EC (HC)*
- *Use of reconstructed tracks*
 - 4) $E = E_0 + (Tracks \text{ swept away by } 4T \text{ field})$
 - 5) $E = EC(e/\gamma + neutral) + HC(neutral) + Tracks$

New

Jet Response and Correction

Et-eta dependent correction for QCD jets

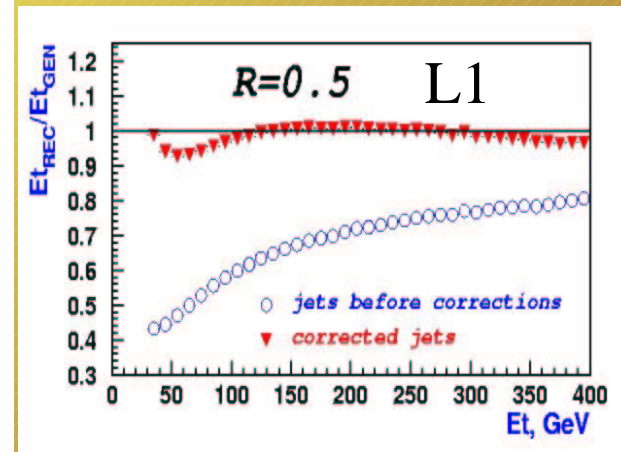
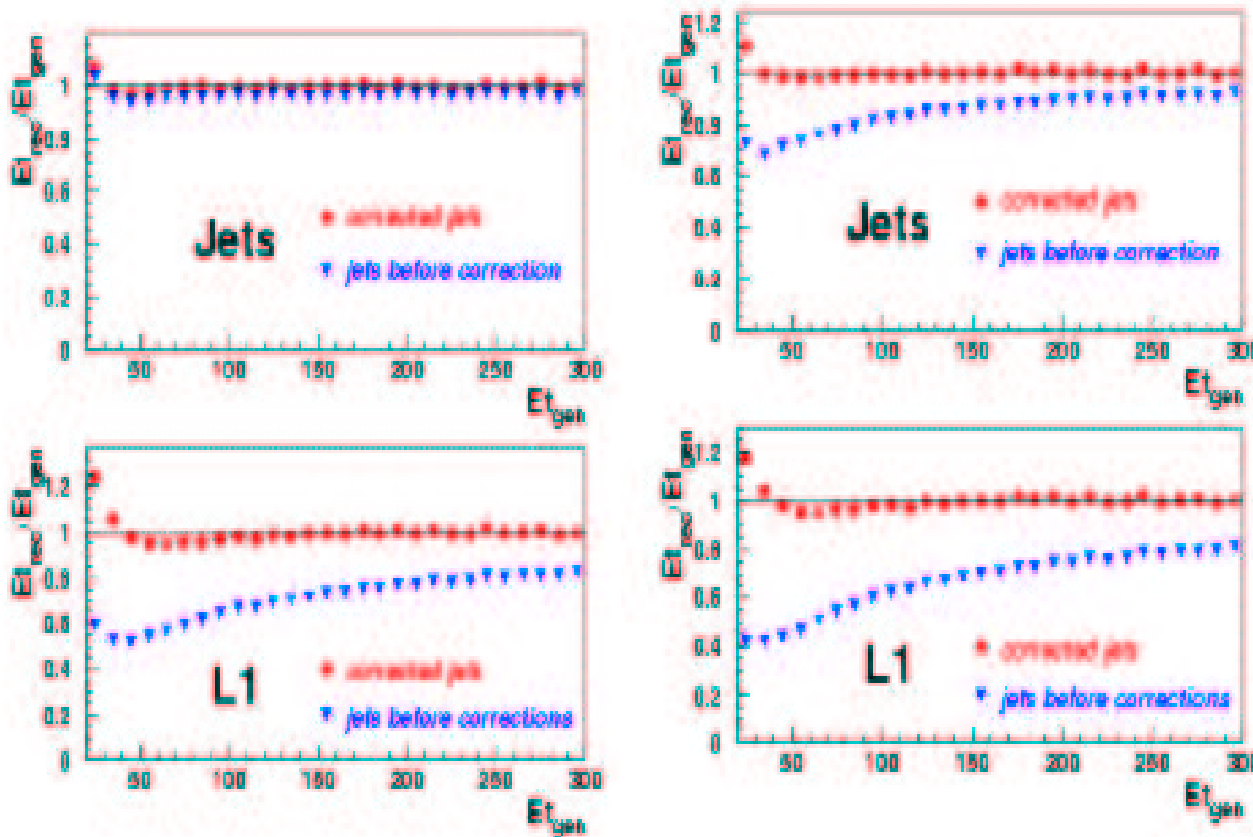
$$Et(\text{corr}) = a + b \times E_T(\text{rec}) + c \times E_T(\text{rec})^2$$

10^{34}

2×10^{33} ORCA6

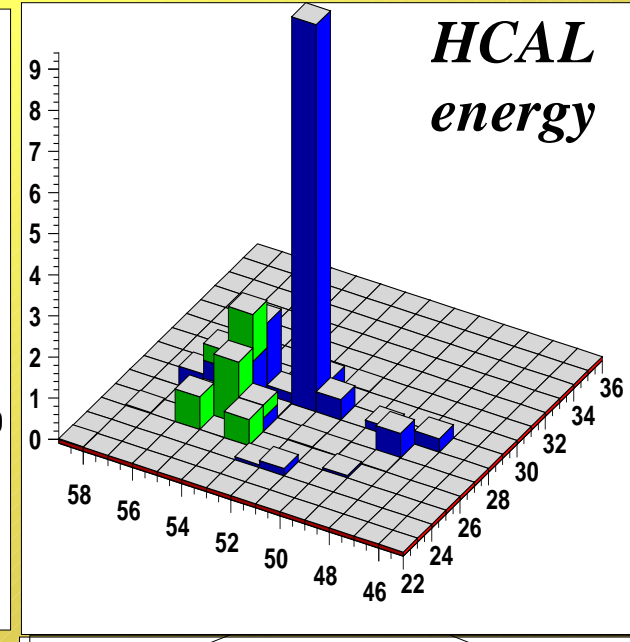
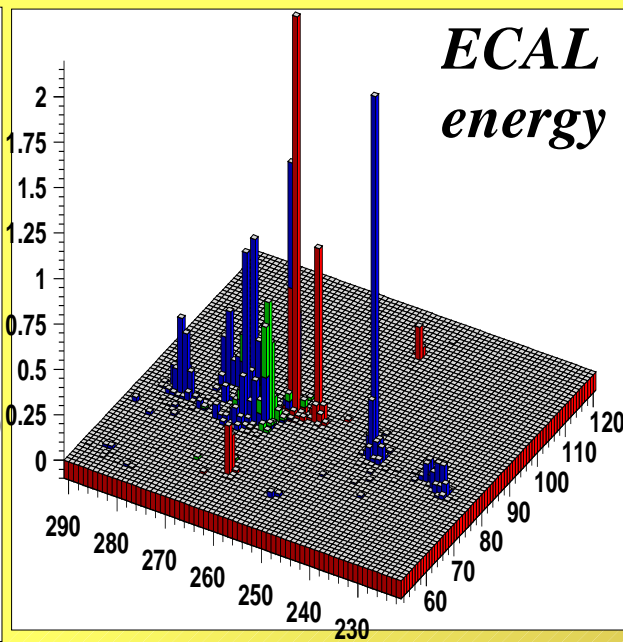
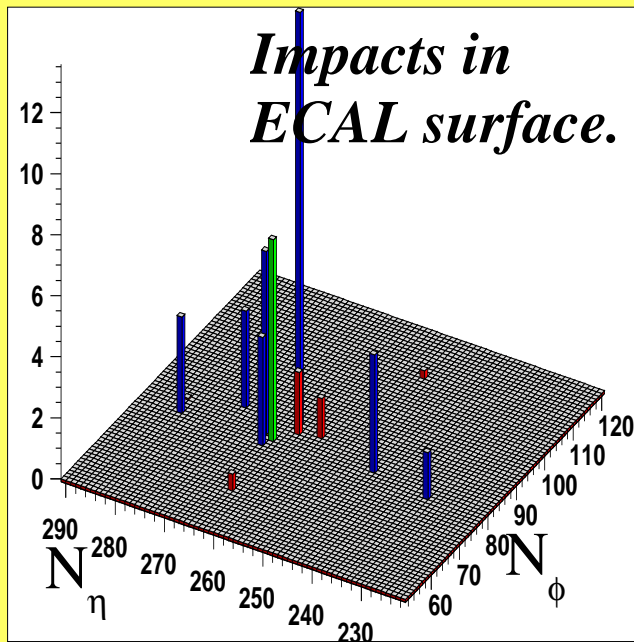
A.Krokhotine

ORCA5



Need to be updated with more statistics.

Using tracker information for jet energy corrections.



✓ *Example (A.Nikitenko): Jet with $E_t = 45$ GeV.*

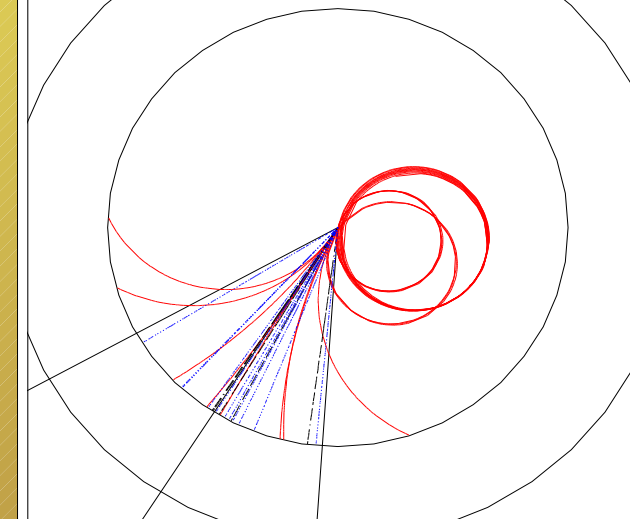
red – photons

blue – charged hadrons

green – neutral hadrons

$$E_{Tjet} = E_{Tjet}^{in\ cone} + P_T^{trks}$$

Jet with $E_t = 100$ GeV.



Jet energy=Response_charged+Response (e/ γ)+Response (neutral)

◆ **Change response of charged hadron of jet to energy from Tracker**

Use energy flow objects inside reco cone (exchange isolated clusters associated with charged track to an energy from tracker)

D.Green.

For overlapping clusters subtract expected response of matched tracks within cone and add $\sum P_T^{trk}$ from tracker.

I.Vardanyan, O.Kodolova

◆ *Use tracks of the jet with impact in calo out of the reco cone.*

A.Nikitenko (already made in ORCA with PixelReconstruction– see talk A.Nikitenko)

**Result: Jet energy=E_TRACKER+Response (e/ γ +neutral)_ECAL+
Response (neutral)_HCAL**

Procedure 3 (O.Kodolova, I.Vardanyan): response subtracting

- ✓ Energy (R(ECAL), R(HCAL)) is calculated in cone around jet axis using standard procedure and with default coefficients.
- ✓ Summarized averaged response from charged particles with entry point inside a cone is subtracted from R(ECAL), R(HCAL).
- ✓ Expected response was calculated in different ways:
**e/π technique (1), library of responses(2), matched cluster(3)
based on isolated particles.**

e/π technique, energy flow objects = matched cluster

(D. Green, CMS NOTE's in draft).

$$E_{EM+neutral}(ECAL) = R(ECAL) - \text{sum}(R_ECAL_i)$$

$$E_{neutral}(HCAL) = R(HCAL) - \text{sum}(R_HCAL_i)$$

$$E_{tracker} = \text{sum}(E_{tracker_i})$$

$$E_{jet} = E_{EM+neutral}(ECAL) + E_{neutral}(HCAL) + E_{tracker}$$

- ✓ Tracks out of cone were added (A.Nikitenko)

New

Dependence of E_T^{reco}/E_T^{MC} on E_T^{MC} jet

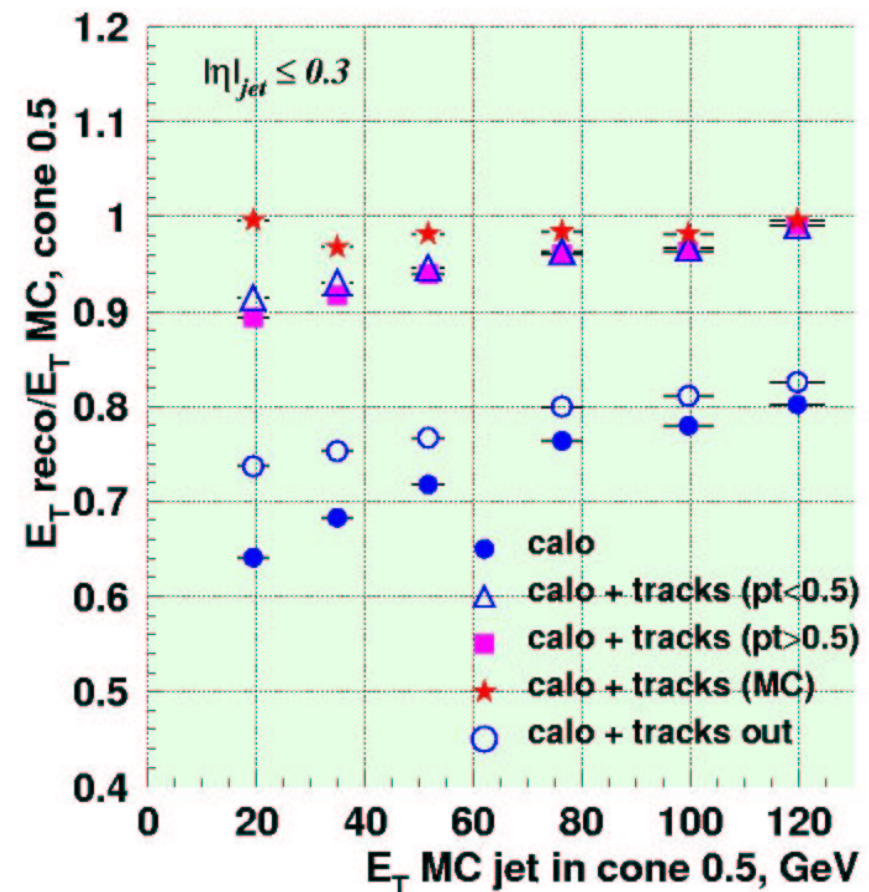
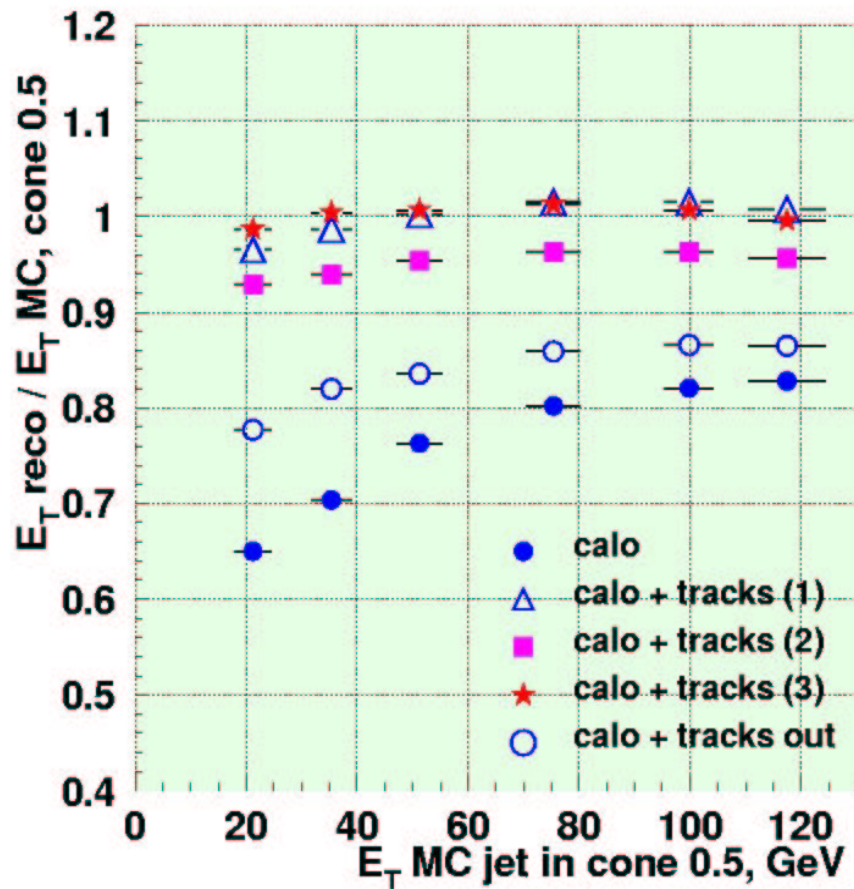
FORTTRAN: *e/π technique+out-of-cone(1)*

library of responses+out-of-cone (2)

matched clusters+

library of responses + out-of-cone (3)

ORCA: *only e/π technique+*
out-of-cone



Open blue circles – only tracks out of cone are added to calo response.

New

Dependence of resolution on E_T MC jet

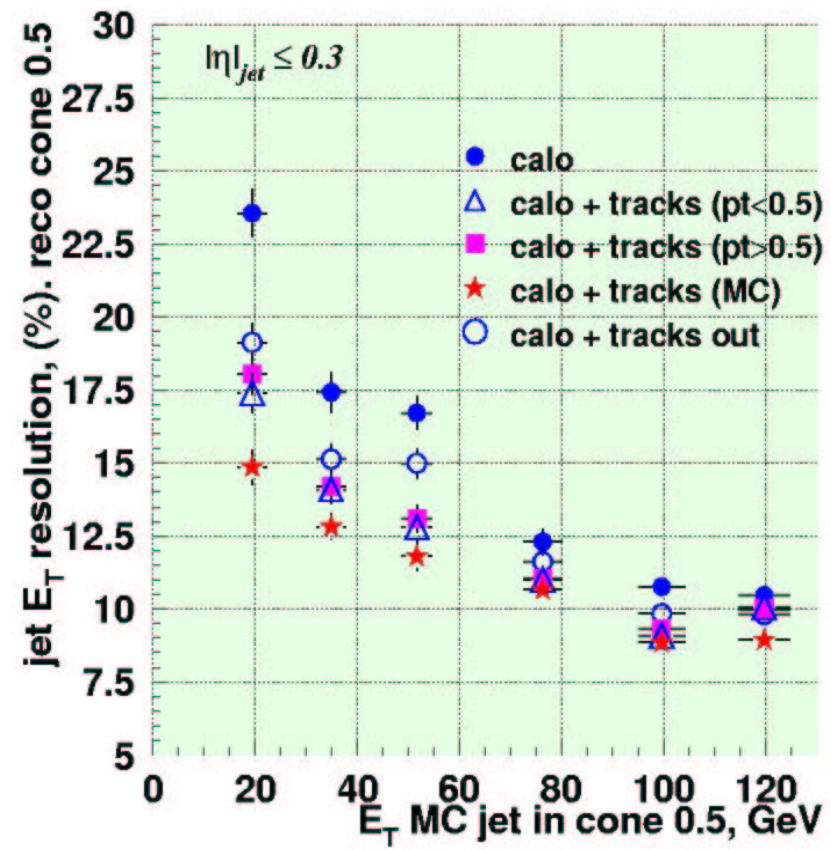
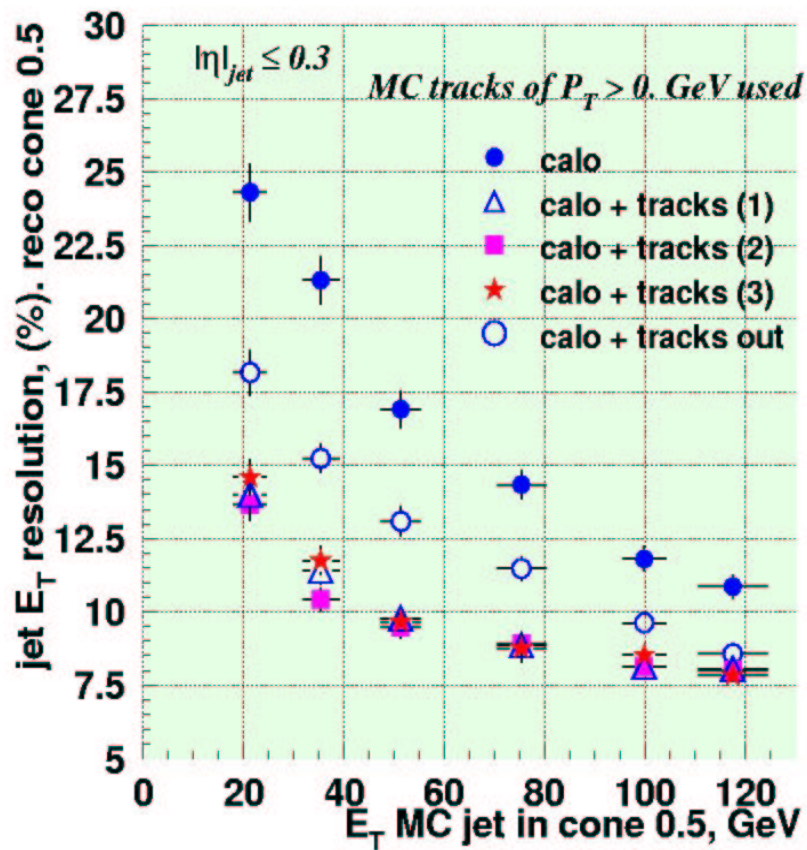
FORTTRAN: *e/π technique+out-of-cone(1)*

library of responses+out-of-cone (2)

matched clusters+

library of responses + out-of-cone (3)

ORCA: *only e/π technique+*
out-of-cone



New

Calibration database

Volodia Ladygin is database manager (please, send him any new information: ladygin@sunhe.jinr.ru)

Collection and maintenance of calibration data (participate in DCS group activity)

The first information is received! But ... no information from HB and HO

HB–HE timing from Vasken Hagopian

Format and example of data on HE megatiles and pigtiles from V.Abramov, A.Korablev

Testbeam in summer – HB with almost final electronics: we hope to receive the first combined data source+beam.

Summary and plans

- ✓ *Collection and maintenance of calibration data (participate in DCS group activity):*

Clarify tasks/responsibilities for operation, analysis, collection, maintenance etc.

*Participate in testbeams: **this summer HB test (and probably HF) with source and beam.***

*Volodia Ladygin is database manager (please, send him any new information: **ladygin@sunhe.jinr.ru**)*

✓ *In-situ calibration:*

γ/Z +jet

- *trigger and data stream requirements.* Two independent investigations show that rate of γ +jet channel with calorimeter and pixel isolation will be on the level of 4 Hz ($ET > 30$ GeV). It should not be any problem with Z+jet channel (rate 0.04Hz). We intend to use ttbar and expect no problems with trigger.

NOTE in preparation

- *background influence and conditions for calibration.*
Beginning from the definite level of signal suppression (50%) the influence of background on calibration with γ +jet channel and Z+jet channel becomes small enough (less than 1 %). Using cut on the energy of second jet one can achieve the condition when ratio $E_{calo}^{jet}/E^{\gamma}$ and $E_{calo}^{jet}/E_{part}^{jet}$ becomes close with accuracy about 1%.

Position of peak K_{jet} divided on weighted radius of jet does not depend on jet initiator but on R of jet.

CMS IN 2002/014

2 NOTE's in preparation.

Z+jet samples from 2002 production are just appeared. Plan more γ +jet in summer production.

Jet energy correction:

Two steps for jet energy corrections: find jet with default fixed coefficients and correct with one of the methods.

➤ *Including tracker information to jet energy measurement gives essential improvement of the jet energy resolution:*

for 20 GeV: from 24% to 14%

for 100 GeV: from 12% to 8%

so as jet energy linearity

Including track reconstruction procedure in ORCA gives:

for 20 GeV: from 24% to 18%

for 100 GeV: from 11% to 9.3%

Including a propagation of MC tracks from vertex in ORCA gives:

for 20 GeV: from 24% to 14%

for 100 GeV: from 11% to 8.9%

CMS NOTE submitted.

CMS NOTE 2002/023

Plan:

to implement algorithm into ORCA with Physics Objects group.

to create a library of responses with single and isolated particles.

to continue support simple energy corrections for new productions and for different algorithms.

jet energy corrections for heavy ions.

➤ *Different calibration channels will be used in complementary mode to achieve the better performance for energy recoverment.*

➤ *hermecity. Perform recalibration with pile up events and selected processes to achieve uniform distribution in eta of energy deposition*

✓ **Monitoring:**

➤ *radiation damages. Endcap and HF part of HCAL will have essential degradation of signal. Corrections can be performed both source and in-situ physical channels.*

CMS NOTE 2002/013
2 NOTE's in preparation

➤ *dead and noisy channels*

Calibration

Calorimeter level energy scale

initial calibration: test beam+source

verify QC during HCAL construction

Object level energy scale (Jet/Met)

Simple /use of tracks/In-situ/pileup

Monitoring

Synchronization

Gain change, Dead/sick channels

Radiation damage

Software tools

Database

Interface

DSC/DAQ-DB interface

ORCA-DB interface

Data Collection and maintenance

– candidates –

– PRS –

A.Gribushin

H.Budd

V.Kolosov

I. Vardanyan

A.Kokhotine

P.Hidas

V.Konnoplianikov

A.Yershov

K.Teplov

– DCS –

P.DeBarbaro

V.Bernes

V.Hagopian

A.Oulianov

T.Kramer

S.Abdullin

V.Ladygin

Need more names,

Esp. from HB/HO